The Avian Eggshell from Çatalhöyük

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The Çatalhöyük eggshell assemblage is unparalleled in size and preservation both in its geographic and temporal situation, and also represents the largest known eggshell assemblage currently recovered archaeologically (Sidell and Scudder 2005). The assemblage has the capacity to inform on human-avian interactions in prehistory, and it is a valuable dataset to be examined alongside the bone record.

Over 940 units have produced eggshell, providing thousands of fragments for analysis (Mulville *et al.* 2014). Eggshell has been recovered mainly through flotation, although there are a number of groups of hand-collected material. There are some large collections of eggshell with several individual contexts revealing numerous fragments, including some fragments of substantial size. To date only a sample of material from a range of feature types and areas relating to two Hodder phases from the 1990-95 excavation seasons had been analysed using SEM (Scanning Electron Microscopy) (Sidell and Scudder 2005). Their results revealed a predominance of duck and goose eggs (Anseriformes), a small number of which had hatched. Other material remained unidentifiable, but was thought to be seabird (possibly gulls, spoonbills or storks), although the remains of these birds are rare on the site.

Eggshell analysis has, until recently, been limited to microscopic SEM analysis, which although providing valuable information, is restricted by expense, requires destructive coating of the samples, and is time consuming. Now microscopy (both SEM and, importantly, high-powered digital microscopy) can be used in conjunction with the analysis of eggshell proteins by mass spectrometry (ZooMS: Buckley *et al*, 2009; Stewart *et al*., 2013), which allows identification of taxon-specific protein markers for avian species present in a reference dataset (Presslee *et al*., in preparation).This is beneficial since it increases the number of samples that can be analysed and identified even where morphologically diagnostic features of the eggshell have been damaged by preservation or by hatching.

For this research forty samples (Table 1) were selected to test and demonstrate the potential of a combined approach to analysing this exceptional eggshell material using ZooMs and microscopic analysis of morphological and metrical criteria. The resorption of calcium from the internal structure of the eggshell was also assessed to determine if an egg was freshly laid/infertile (and as such likely used as a food resource), or if it came from eggs that had been allowed to hatch.

Results

Species

The results confirm that Anseriformes dominate the avian eggshell assemblage. Mass spectrometry has identified the majority of the analysed samples as duck, (but other Anseriformes may also be present – see below), possibly belonging to at least two different genera/species, on the basis of visual examination of the mass spectra. Microscopy has also revealed through observation of internal surface characteristics such as the mammillae and via counts and metrical analysis of the eggshell's morphological features that multiple species of duck are likely to be represented, and, although these cannot currently be assigned to specific species, this diversity is in agreement with the bone analysis (Russell and McGowan 2005). The thickness of several of the eggshells extends beyond the known average range for many duck species (Figure 1), however duck eggshell thickness is very varied and the comparative dataset of metrical data from different duck species is incomplete. Additionally there is an overlap in size data between species of ducks and other Anseriformes such as geese (Keepax 1981; Sidell 1993).

There are a range of potential geese species that could be present however *Anser* geese were not identified during ZooMS analysis of the samples, making it unlikely that these grey geese comprise much of the eggshell assemblage. This again supports the bone data as the most commonly identified grey geese (White-fronted Goose [*Anser albifrons*] and Lesser White-fronted Goose [*Anser erythropus*]) today do not breed in the area, and the bones did not appear to be large enough to represent Greylag goose (*Anser anser*), which does breed in the area (Russell and McGowan 2005). Further sequencing of the proteins from reference eggshell is needed for other related Anseriformes (such as black geese [*Branta*] and swans). Until then their presence cannot be eliminated using this technique.

One of the samples has been identified by mass spectrometry (protein sequencing) as crane. This specimen (Zc34) came from unit 30625, a Neolithic midden layer. Crane bone has previously been identified in the assemblage in small quantities (Russell and McGowan 2005; Mulville *et al*. 2014).

Developmental Stage

Analysis of internal structure of the eggshell revealed that the majority of the samples analysed were derived from unhatched eggs. Within the Anseriformes a small number of the eggs exhibited the first stages of resorption caused by the growth of a chick within the egg, demonstrating that these eggs were fertile (Figure 2). At least two of the probable duck samples come from eggs that are very late in the developmental sequence indicating that a small number of live birds may have been hatching in the vicinity of the site.

The crane eggshell specimen showed no signs of hatching and was thus from a freshly laid egg (or infertile) (Figure 3).

Sum

In conclusion, this analysis suggests that egg exploitation largely focused on Anseriformes, with a range of duck species represented. There are also potentially geese species present but further work is needed to clarify this. Smaller, but significant contributions were provided by crane. Considering the potentially special and ritual role held by crane at Çatalhöyük this is a valuable find which expands our knowledge of interactions between humans and these birds.

Developmental evidence suggests that the eggs, being largely unhatched, would have provided a valuable food resource, but their role could have ranged from utilisation in pigment production to ritual significance.

The quantity of avian eggshell present at Çatalhöyük could potentially indicate early management of waterfowl which would be of international significance. Due to the scale of the assemblage this work needs to be continued on a larger proportion of material in order to clarify its taxonomic makeup accurately and to fully explore the roles that these different birds may have played. This unique avian assemblage is a prime candidate for further analysis. Continuing developments in the field of ZooMS analysis will allow increased examination of larger numbers of fragments, whilst integration with digital microscopy enables fast, non-destructive analysis of hatching profiles and morphology, and facilitates targeted SEM analysis of smaller subsamples.

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Figure 1a&b: Probable duck eggshell with unusual thickness requiring further exploration (Photos J. Best).

Figure 2: Duck eggshell with evidence of chick development (Photo J. Best).

Figure 3: Crane eggshell with no evidence of resorption from chick development (Photo J. Best).

Table 1: Samples examined by mass spectrometry

Sample ID	Unit	Year	Mound	Area	Time period	Hodder Level	Building	Space	Feature	Interpretive Category	Flot. Number
Zc1	18174	2009	East	South	Neolithic	South.P		132		dump, external	8850
Zc2	18174	2009	East	South	Neolithic	South.P		132		dump, external	8850
Zc3	18174	2009	East	South	Neolithic	South.P		132		dump, external	8850
Zc4	18174	2009	East	South	Neolithic	South.P		132		dump, external	8950
Zc5	18174	2009	East	South	Neolithic	South.P		132		dump, external	8850
Zc6	19564	2012	East	North	Neolithic			489		Midden Arbitrary Layer	10164
Zc7	19564	2012	East	North	Neolithic			489		Midden Arbitrary Layer	10164
Zc8	19564	2012	East	North	Neolithic			489		Midden Arbitrary Layer	10164
Zc9	14012	2006	East	South	Neolithic	South.Q	65	297	2096	ash dump/midden	7001
Zc10	19564	2012	East	North	Neolithic			489		Midden Arbitrary Layer	10164
Zc11	19564	2012	East	North	Neolithic			489		Midden Arbitrary Layer	10164
Zc12	13191	2006	East	4040	Post-Chalcolithic	4040.Post-Chalcolithic		1002	2247	burial fill	6982
Zc13	12654	2006	East	4040	Neolithic	4040.I		279		midden layer	6702
Zc14	19380	2011	East	South	Neolithic	South.M		470	4098	Fill	9672
Zc15	14126	2006	East	4040	Neolithic	4040.I		279		Midden	7075
Zc16	14126	2006	East	4040	Neolithic	4040.I		280		Midden	7075
Zc17	14315	2006	East	South	Neolithic	South.Q	53	257		make up	7160
Zc18	13182	2006	East	4040	Post-Chalcolithic	4040.Post-Chalcolithic		1002	2245	fill of grave	6927
Zc19	13182	2006	East	4040	Post-Chalcolithic	4040.Post-Chalcolithic		1002	2245	fill of grave	6927
Zc20	13182	2006	East	4040	Post-Chalcolithic	4040.Post-Chalcolithic		1002	2245	fill of grave	6927
Zc21	11369	2005	East	South	Neolithic	South.Q		260		Midden,room fill	6107
Zc22	19114	2010	East	South	Neolithic	South.P		344		midden layer	9233
Zc23	19114	2010	East	South	Neolithic	South.P		344		midden layer	9233

Zc24	13103	2006	East	4040	Neolithic	4040.I		279		midden layer	6567
Zc25	13103	2006	East	4040	Neolithic	4040.I		279		midden layer	6567
Zc26	13151	2006	East	4040	Neolithic	4040.I		279		Scorched layer	6776
Zc27	13151	2006	East	4040	Neolithic	4040.I		279		Scorched layer	6776
Zc28	19245	2011	East	South	Neolithic	South.O	97	365	3520	Robber fill	9516
Zc29	19245	2011	East	South	Neolithic	South.O	97	365	3520	Robber fill	9516
Zc30	12508	2006	East	South	Neolithic	South.P		132		midden	6747
Zc31	19116	2010	East	South	Neolithic	South.P		344		Midden Layer	9215
Zc32	12654	2006	East	4040	Neolithic	4040.I		279		midden layer	6701
Zc33	12654	2006	East	4040	Neolithic	4040.I		279		midden layer	6701
Zc34	30625	2013	East	South	Neolithic	South.H	118	510		Midden layer in Sw section	10743
Zc35	18192	2009	East	South	Neolithic	South.P		372		midden	9011
Zc36	18192	2009	East	South	Neolithic	South.P		372		midden	9011
Zc37	18192	2009	East	South	Neolithic	South.P		372		midden	9011
Zc38	11367	2005	East	South	Neolithic	South.Q		260		Midden	6060
Zc39	11367	2005	East	South	Neolithic	South.Q		260		Midden	6060
Zc40	11367	2005	East	South	Neolithic	South.Q		260		Midden	6060